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Marcia D. Shea  
Marcia D. Shea

Date: July 29, 1998

Assistant Commissioner for Patents

U.S. PATENT APPLICATIONS

Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of:

Inventors: James M. BARTON, Roderick James McINNIS, Alan S. MOSKOWITZ,  
Andrew Martin GOODMAN, Ching Tong CHOW, Jean Swey KAO

For: MULTIMEDIA TIME WARPING SYSTEM

Docket No.: TIVO0003

Enclosed are:

- (X) 13 sheets of drawings
- (X) A copy of a patent application
- (X) A declaration and power of attorney
- (X) An assignment of the invention to: TIVO, INC.
- (X) Verified Statement Claiming Small Entity Status- Individual
- (X) Verified Statement Claiming Small Entity Status- Business
- (X) An Information Disclosure Statement, 1449 Form and cited references
- (X) One self addressed postcard

The filing fee has been calculated as shown below:

Fee Calculation ( small entity )					
Fee	Claims	Included with	Extra		
Items	Filed	Basic Fee	Claims	Fee Rate	Total
Total Claims	61	20	41	\$ 11.00	\$ 451.00
Independent Claims	4	3	1	\$ 41.00	\$ 41.00
Multiple Dependent Claim Fee ( for one or more )				\$ 135.00	
Assignment Recordation Fee				\$ 40.00	\$ 40.00
Basic Filing Fee				\$ 395.00	\$ 395.00
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A check in the amount of \$927 is enclosed to cover the filing fee and assignment recording fee.

The Commissioner is authorized to charge any additional fees or credit any overpayments to Deposit Account No. 07-1445 ( Order No. TIVO0003). A copy of this sheet is enclosed for accounting purposes.

All correspondence connected herewith should be sent to:

Michael A. Glenn  
P.O. Box 7831  
Menlo Park, CA 94026

All telephone calls connected herewith should be directed to:

Michael A. Glenn (650) 851-7138

Respectfully submitted,

Michael A. Glenn  
Michael A. Glenn  
Reg. No. 30,176

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# MULTIMEDIA TIME WARPING SYSTEM

## BACKGROUND OF THE INVENTION

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### TECHNICAL FIELD

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The invention relates to the time shifting of television broadcast signals. More particularly, the invention relates to the real time capture, storage, and display of television broadcast signals.

### DESCRIPTION OF THE PRIOR ART

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The Video Cassette Recorder (VCR) has changed the lives of television (TV) viewers throughout the world. The VCR has offered viewers the flexibility to time-shift TV programs to match their lifestyles.

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The viewer stores TV programs onto magnetic tape using the VCR. The VCR gives the viewer the ability to play, rewind, fast forward and pause the stored program material. These functions enable the viewer to pause the program playback whenever he desires, fast forward through unwanted program material or commercials, and to replay favorite scenes. However, a VCR cannot both capture and play back information at the same time.

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One approach to solving this problem is to use several VCRs. For example, if two video tape recorders are available, it might be possible to Ping-Pong between the two. In this case, the first recorder is started at the beginning of the program of interest. If the viewer wishes to rewind the broadcast, the second

recorder begins recording, while the first recorder is halted, rewound to the appropriate place, and playback initiated. However, at least a third video tape recorder is required if the viewer wishes to fast forward to some point in time after the initial rewind was requested. In this case, the third recorder starts recording the broadcast stream while the second is halted and rewound to the appropriate position. Continuing this exercise, one can quickly see that the equipment becomes unwieldy, unreliable, expensive, and hard to operate, while never supporting all desired functions. In addition, tapes are of finite length, and may potentially end at inconvenient times, drastically lowering the value of the solution.

The use of digital computer systems to solve this problem has been suggested. U.S. Pat. No. 5,371,551 issued to Logan *et al.*, on 6 December 1994, teaches a method for concurrent video recording and playback. It presents a microprocessor controlled broadcast and playback device. Said device compresses and stores video data onto a hard disk. However, this approach is difficult to implement because the processor requirements for keeping up with the high video rates makes the device expensive and problematic. The microprocessor must be extremely fast to keep up with the incoming and outgoing video data.

It would be advantageous to provide a multimedia time warping system that gives the user the ability to simultaneously record and play back TV broadcast programs. It would further be advantageous to provide a multimedia time warping system that utilizes an approach that decouples the microprocessor from the high video data rates, thereby reducing the microprocessor and system requirements which are at a premium.

**SUMMARY OF THE INVENTION**

The invention provides a multimedia time warping system. The invention utilizes an easily manipulated, low cost multimedia storage and display system that allows the user to view a television broadcast program with the option of instantly reviewing previous scenes within the program. In addition, the invention allows the user to store selected television broadcast programs while the user is simultaneously watching or reviewing another program.

A preferred embodiment of the invention accepts television (TV) input streams in a multitude of forms, for example, analog forms such as National Television Standards Committee (NTSC) or PAL broadcast, and digital forms such as Digital Satellite System (DSS), Digital Broadcast Services (DBS), or Advanced Television Standards Committee (ATSC). Analog TV streams are converted to an Moving Pictures Experts Group (MPEG) formatted stream for internal transfer and manipulation, while pre-formatted MPEG streams are extracted from the digital TV signal and presented in a similar format to encoded analog streams.

The invention parses the resulting MPEG stream and separates it into its video and audio components. It then stores the components into temporary buffers. Events are recorded that indicate the type of component that has been found, where it is located, and when it occurred. The program logic is notified that an event has occurred and the data is extracted from the buffers.

The parser and event buffer decouple the CPU from having to parse the MPEG stream and from the real time nature of the data streams. This decoupling allows for slower CPU and bus speeds which translate to lower system costs.

The video and audio components are stored on a storage device. When the program is requested for display, the video and audio components are extracted from the storage device and reassembled into an MPEG stream. The MPEG stream is sent to a decoder. The decoder converts the MPEG stream into TV output signals and delivers the TV output signals to a TV receiver.

User control commands are accepted and sent through the system. These commands affect the flow of said MPEG stream and allow the user to view stored programs with at least the following functions: reverse, fast forward, play, pause, index, fast/slow reverse play, and fast/slow play.

Other aspects and advantages of the invention will become apparent from the following detailed description in combination with the accompanying drawings, illustrating, by way of example, the principles of the invention.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a block schematic diagram of a high level view of a preferred embodiment of the invention according to the invention;

Fig. 2 is a block schematic diagram of a preferred embodiment of the invention using multiple input and output modules according to the invention;

Fig. 3 is a schematic diagram of an Moving Pictures Experts Group (MPEG) data stream and its video and audio components according to the invention;

Fig. 4 is a block schematic diagram of a parser and four direct memory access (DMA) input engines contained in the Media Switch according to the invention;

Fig. 5 is a schematic diagram of the components of a packetized elementary stream (PES) buffer according to the invention;

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Fig. 6 is a schematic diagram of the construction of a PES buffer from the parsed components in the Media Switch output circular buffers;

Fig. 7 is a block schematic diagram of the Media Switch and the various components that it communicates with according to the invention;

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Fig. 8 is a block schematic diagram of a high level view of the program logic according to the invention;

Fig. 9 is a block schematic diagram of a class hierarchy of the program logic according to the invention;

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Fig. 10 is a block schematic diagram of a preferred embodiment of the clip cache component of the invention according to the invention;

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Fig. 11 is a block schematic diagram of a preferred embodiment of the invention that emulates a broadcast studio video mixer according to the invention;

Fig. 12 is a block schematic diagram of a closed caption parser according to the invention; and

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Fig. 13 is a block schematic diagram of a high level view of a preferred embodiment of the invention utilizing a VCR as an integral component of the invention according to the invention.

## **DETAILED DESCRIPTION OF THE INVENTION**

5 The invention is embodied in a multimedia time warping system. A system according to the invention provides a multimedia storage and display system that allows the user to view a television broadcast program with the option of instantly reviewing previous scenes within the program. The invention additionally provides the user with the ability to store selected television broadcast programs while simultaneously watching or reviewing another program and to view stored programs with at least the following functions:  
10 reverse, fast forward, play, pause, index, fast/slow reverse play, and fast/slow play.

15 Referring to Fig. 1, a preferred embodiment of the invention has an Input Section 101, Media Switch 102, and an Output Section 103. The Input Section 101 takes television (TV) input streams in a multitude of forms, for example, National Television Standards Committee (NTSC) or PAL broadcast, and digital forms such as Digital Satellite System (DSS), Digital Broadcast Services (DBS), or Advanced Television Standards Committee (ATSC). DBS, DSS and ATSC are based on standards called Moving Pictures Experts Group 2 (MPEG2) and MPEG2 Transport. MPEG2 Transport is a standard for formatting the digital data stream from the TV source transmitter so that a TV receiver can disassemble the input stream to find programs in the multiplexed signal. The Input Section 101 produces MPEG streams. An MPEG2 transport multiplex supports multiple programs in the same broadcast channel, with multiple video and audio feeds and private data. The Input Section 101 tunes the channel to a particular program, extracts a specific MPEG program out of it, and feeds it to the rest of the system. Analog TV signals are encoded into a similar MPEG format using separate video and audio encoders, such that the remainder of the system is unaware of how the signal was obtained. Information may be  
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modulated into the Vertical Blanking Interval (VBI) of the analog TV signal in a number of standard ways; for example, the North American Broadcast Teletext Standard (NABTS) may be used to modulate information onto lines 10 through 20 of an NTSC signal, while the FCC mandates the use of line 21 for Closed Caption (CC) and Extended Data Services (EDS). Such signals are decoded by the input section and passed to the other sections as if they were delivered via an MPEG2 private data channel.

The Media Switch 102 mediates between a microprocessor CPU 106, hard disk or storage device 105, and memory 104. Input streams are converted to an MPEG stream and sent to the Media Switch 102. The Media Switch 102 buffers the MPEG stream into memory. It then performs two operations if the user is watching real time TV: the stream is sent to the Output Section 103 and it is written simultaneously to the hard disk or storage device 105.

The Output Section 103 takes MPEG streams as input and produces an analog TV signal according to the NTSC, PAL, or other required TV standards. The Output Section 103 contains an MPEG decoder, On-Screen Display (OSD) generator, analog TV encoder and audio logic. The OSD generator allows the program logic to supply images which will be overlayed on top of the resulting analog TV signal. Additionally, the Output Section can modulate information supplied by the program logic onto the VBI of the output signal in a number of standard formats, including NABTS, CC and EDS.

With respect to Fig. 2, the invention easily expands to accommodate multiple Input Sections (tuners) 201, 202, 203, 204, each can be tuned to different types of input. Multiple Output Modules (decoders) 206, 207, 208, 209 are added as well. Special effects such as picture in a picture can be implemented with multiple decoders. The Media Switch 205 records one program while the user



is watching another. This means that a stream can be extracted off the disk while another stream is being stored onto the disk.

Referring to Fig. 3, the incoming MPEG stream 301 has interleaved video 302, 305, 306 and audio 303, 304, 307 segments. These elements must be separated and recombined to create separate video 308 and audio 309 streams or buffers. This is necessary because separate decoders are used to convert MPEG elements back into audio or video analog components. Such separate delivery requires that time sequence information be generated so that the decoders may be properly synchronized for accurate playback of the signal.

The Media Switch enables the program logic to associate proper time sequence information with each segment, possibly embedding it directly into the stream. The time sequence information for each segment is called a time stamp. These time stamps are monotonically increasing and start at zero each time the system boots up. This allows the invention to find any particular spot in any particular video segment. For example, if the system needs to read five seconds into an incoming contiguous video stream that is being cached, the system simply has to start reading forward into the stream and look for the appropriate time stamp.

A binary search can be performed on a stored file to index into a stream. Each stream is stored as a sequence of fixed-size segments enabling fast binary searches because of the uniform time stamping. If the user wants to start in the middle of the program, the system performs a binary search of the stored segments until it finds the appropriate spot, obtaining the desired results with a minimal amount of information. If the signal were instead stored as an MPEG stream, it would be necessary to linearly parse the stream from the beginning to find the desired location.

With respect to Fig. 4, the Media Switch contains four input Direct Memory Access (DMA) engines 402, 403, 404, 405 each DMA engine has an associated buffer 410, 411, 412, 413. Conceptually, each DMA engine has a pointer 406, a limit for that pointer 407, a next pointer 408, and a limit for the next pointer 409. Each DMA engine is dedicated to a particular type of information, for example, video 402, audio 403, and parsed events 405. The buffers 410, 411, 412, 413 are circular and collect the specific information. The DMA engine increments the pointer 406 into the associated buffer until it reaches the limit 407 and then loads the next pointer 408 and limit 409. Setting the pointer 406 and next pointer 408 to the same value, along with the corresponding limit value creates a circular buffer. The next pointer 408 can be set to a different address to provide vector DMA.

The input stream flows through a parser 401. The parser 401 parses the stream looking for MPEG distinguished events indicating the start of video, audio or private data segments. For example, when the parser 401 finds a video event, it directs the stream to the video DMA engine 402. The parser 401 buffers up data and DMAs it into the video buffer 410 through the video DMA engine 402. At the same time, the parser 401 directs an event to the event DMA engine 405 which generates an event into the event buffer 413. When the parser 401 sees an audio event, it redirects the byte stream to the audio DMA engine 403 and generates an event into the event buffer 413. Similarly, when the parser 401 sees a private data event, it directs the byte stream to the private data DMA engine 404 and directs an event to the event buffer 413. The Media Switch notifies the program logic via an interrupt mechanism when events are placed in the event buffer.

Referring to Figs. 4 and 5, the event buffer 413 is filled by the parser 401 with events. Each event 501 in the event buffer has an offset 502, event type 503, and time stamp field 504. The parser 401 provides the type and offset of each event as it is placed into the buffer. For example, when an audio event occurs, the event type field is set to an audio event and the offset indicates the location in the audio buffer 411. The program logic knows where the audio buffer 411 starts and adds the offset to find the event in the stream. The address offset 502 tells the program logic where the next event occurred, but not where it ended. The previous event is cached so the end of the current event can be found as well as the length of the segment.

With respect to Figs. 5 and 6, the program logic reads accumulated events in the event buffer 602 when it is interrupted by the Media Switch 601. From these events the program logic generates a sequence of logical segments 603 which correspond to the parsed MPEG segments 615. The program logic converts the offset 502 into the actual address 610 of each segment, and records the event length 609 using the last cached event. If the stream was produced by encoding an analog signal, it will not contain Program Time Stamp (PTS) values, which are used by the decoders to properly present the resulting output. Thus, the program logic uses the generated time stamp 504 to calculate a simulated PTS for each segment and places that into the logical segment time stamp 607. In the case of a digital TV stream, PTS values are already encoded in the stream. The program logic extracts this information and places it in the logical segment time stamp 607.

The program logic continues collecting logical segments 603 until it reaches the fixed buffer size. When this occurs, the program logic generates a new buffer, called a Packetized Elementary Stream (PES) 605 buffer containing these logical segments 603 in order, plus ancillary control information. Each logical

segment points 604 directly to the circular buffer, *e.g.*, the video buffer 613, filled by the Media Switch 601. This new buffer is then passed to other logic components, which may further process the stream in the buffer in some way, such as presenting it for decoding or writing it to the storage media. Thus, the MPEG data is not copied from one location in memory to another by the processor. This results in a more cost effective design since lower memory bandwidth and processor bandwidth is required.

A unique feature of the MPEG stream transformation into PES buffers is that the data associated with logical segments need not be present in the buffer itself, as presented above. When a PES buffer is written to storage, these logical segments are written to the storage medium in the logical order in which they appear. This has the effect of gathering components of the stream, whether they be in the video, audio or private data circular buffers, into a single linear buffer of stream data on the storage medium. The buffer is read back from the storage medium with a single transfer from the storage media, and the logical segment information is updated to correspond with the actual locations in the buffer 606. Higher level program logic is unaware of this transformation, since it handles only the logical segments, thus stream data is easily managed without requiring that the data ever be copied between locations in DRAM by the CPU.

A unique aspect of the Media Switch is the ability to handle high data rates effectively and inexpensively. It performs the functions of taking video and audio data in, sending video and audio data out, sending video and audio data to disk, and extracting video and audio data from the disk on a low cost platform. Generally, the Media Switch runs asynchronously and autonomously with the microprocessor CPU, using its DMA capabilities to move large quantities of information with minimal intervention by the CPU.

Referring to Fig: 7, the input side of the Media Switch 701 is connected to an MPEG encoder 703. There are also circuits specific to MPEG audio 704 and vertical blanking interval (VBI) data 702 feeding into the Media Switch 701. If a digital TV signal is being processed instead, the MPEG encoder 703 is replaced with an MPEG2 Transport Demultiplexor, and the MPEG audio encoder 704 and VBI decoder 702 are deleted. The demultiplexor multiplexes the extracted audio, video and private data channel streams through the video input Media Switch port.

The parser 705 parses the input data stream from the MPEG encoder 703, audio encoder 704 and VBI decoder 702, or from the transport demultiplexor in the case of a digital TV stream. The parser 705 detects the beginning of all of the important events in a video or audio stream, the start of all of the frames, the start of sequence headers - all of the pieces of information that the program logic needs to know about in order to both properly play back and perform special effects on the stream, e.g. fast forward, reverse, play, pause, fast/slow play, indexing, and fast/slow reverse play.

The parser 705 places tags 707 into the FIFO 706 when it identifies video or audio segments, or is given private data. The DMA 709 controls when these tags are taken out. The tags 707 and the DMA addresses of the segments are placed into the event queue 708. The frame type information, whether it is a start of a video I-frame, video B-frame, video P-frame, video PES, audio PES, a sequence header, an audio frame, or private data packet, is placed into the event queue 708 along with the offset in the related circular buffer where the piece of information was placed. The program logic operating in the CPU 713 examines events in the circular buffer after it is transferred to the DRAM 714.

The Media Switch 701 has a data bus 711 that connects to the CPU 713 and DRAM 714. An address bus 712 is also shared between the Media Switch 701, CPU 713, and DRAM 714. A hard disk or storage device 710 is connected to one of the ports of the Media Switch 701. The Media Switch 701 outputs streams to an MPEG video decoder 715 and a separate audio decoder 717. The audio decoder 717 signals contain audio cues generated by the system in response to the user's commands on a remote control or other internal events. The decoded audio output from the MPEG decoder is digitally mixed 718 with the separate audio signal. The resulting signals contain video, audio, and on-screen displays and are sent to the TV 716.

The Media Switch 701 takes in 8-bit data and sends it to the disk, while at the same time extracts another stream of data off of the disk and sends it to the MPEG decoder 715. All of the DMA engines described above can be working at the same time. The Media Switch 701 can be implemented in hardware using a Field Programmable Gate Array (FPGA), ASIC, or discrete logic.

Rather than having to parse through an immense data stream looking for the start of where each frame would be, the program logic only has to look at the circular event buffer in DRAM 714 and it can tell where the start of each frame is and the frame type. This approach saves a large amount of CPU power, keeping the real time requirements of the CPU 713 small. The CPU 713 does not have to be very fast at any point in time. The Media Switch 701 gives the CPU 713 as much time as possible to complete tasks. The parsing mechanism 705 and event queue 708 decouple the CPU 713 from parsing the audio, video, and buffers and the real time nature of the streams, which allows for lower costs. It also allows the use of a bus structure in a CPU environment that operates at a much lower clock rate with much cheaper memory than would be required otherwise.

5 The CPU 713 has the ability to queue up one DMA transfer and can set up the  
next DMA transfer at its leisure. This gives the CPU 713 large time intervals  
within which it can service the DMA controller 709. The CPU 713 may respond  
to a DMA interrupt within a larger time window because of the large latency  
10 allowed. MPEG streams, whether extracted from an MPEG2 Transport or  
encoded from an analog TV signal, are typically encoded using a technique  
called Variable Bit Rate encoding (VBR). This technique varies the amount of  
data required to represent a sequence of images by the amount of movement  
15 between those images. This technique can greatly reduce the required  
bandwidth for a signal, however sequences with rapid movement (such as a  
basketball game) may be encoded with much greater bandwidth requirements.  
For example, the Hughes DirecTV satellite system encodes signals with  
anywhere from 1 to 10Mb/s of required bandwidth, varying from frame to frame.  
It would be difficult for any computer system to keep up with such rapidly varying  
data rates without this structure.

20 With respect to Fig. 8, the program logic within the CPU has three conceptual  
components: sources 801, transforms 802, and sinks 803. The sources 801  
produce buffers of data. Transforms 802 process buffers of data and sinks 803  
consume buffers of data. A transform is responsible for allocating and queuing  
the buffers of data on which it will operate. Buffers are allocated as if "empty" to  
sources of data, which give them back "full". The buffers are then queued and  
given to sinks as "full", and the sink will return the buffer "empty".

25 A source 801 accepts data from encoders, *e.g.*, a digital satellite receiver. It  
acquires buffers for this data from the downstream transform, packages the data  
into a buffer, then pushes the buffer down the pipeline as described above. The  
source object 801 does not know anything about the rest of the system. The

sink 803 consumes buffers, taking a buffer from the upstream transform, sending the data to the decoder, and then releasing the buffer for reuse.

There are two types of transforms 802 used: spatial and temporal. Spatial transforms are transforms that perform, for example, an image convolution or compression/decompression on the buffered data that is passing through. Temporal transforms are used when there is no time relation that is expressible between buffers going in and buffers coming out of a system. Such a transform writes the buffer to a file 804 on the storage medium. The buffer is pulled out at a later time, sent down the pipeline, and properly sequenced within the stream.

Referring to Fig. 9, a C++ class hierarchy derivation of the program logic is shown. The TiVo Media Kernel (Tmk) 904, 908, 913 mediates with the operating system kernel. The kernel provides operations such as: memory allocation, synchronization, and threading. The TmkCore 904, 908, 913 structures memory taken from the media kernel as an object. It provides operators, new and delete, for constructing and deconstructing the object. Each object (source 901, transform 902, and sink 903) is multi-threaded by definition and can run in parallel.

The TmkPipeline class 905, 909, 914 is responsible for flow control through the system. The pipelines point to the next pipeline in the flow from source 901 to sink 903. To pause the pipeline, for example, an event called "pause" is sent to the first object in the pipeline. The event is relayed on to the next object and so on down the pipeline. This all happens asynchronously to the data going through the pipeline. Thus, similar to applications such as telephony, control of the flow of MPEG streams is asynchronous and separate from the streams themselves. This allows for a simple logic design that is at the same time powerful enough to support the features described previously, including pause,



rewind, fast forward and others. In addition, this structure allows fast and efficient switching between stream sources, since buffered data can be simply discarded and decoders reset using a single event, after which data from the new stream will pass down the pipeline. Such a capability is needed, for example, when switching the channel being captured by the input section, or when switching between a live signal from the input section and a stored stream.

The source object 901 is a TmkSource 906 and the transform object 902 is a TmkXfrm 910. These are intermediate classes that define standard behaviors for the classes in the pipeline. Conceptually, they handshake buffers down the pipeline. The source object 901 takes data out of a physical data source, such as the Media Switch, and places it into a PES buffer. To obtain the buffer, the source object 901 asks the down stream object in his pipeline for a buffer (allocEmptyBuf). The source object 901 is blocked until there is sufficient memory. This means that the pipeline is self-regulating; it has automatic flow control. When the source object 901 has filled up the buffer, it hands it back to the transform 902 through the pushFullBuf function.

The sink 903 is flow controlled as well. It calls nextFullBuf which tells the transform 902 that it is ready for the next filled buffer. This operation can block the sink 903 until a buffer is ready. When the sink 903 is finished with a buffer (*i.e.*, it has consumed the data in the buffer) it calls releaseEmptyBuf. ReleaseEmptyBuf gives the buffer back to the transform 902. The transform 902 can then hand that buffer, for example, back to the source object 901 to fill up again. In addition to the automatic flow-control benefit of this method, it also provides for limiting the amount of memory dedicated to buffers by allowing enforcement of a fixed allocation of buffers by a transform. This is an important feature in achieving a cost-effective limited DRAM environment.

The MediaSwitch class 909 calls the allocEmptyBuf method of the TmkClipCache 912 object and receives a PES buffer from it . It then goes out to the circular buffers in the Media Switch hardware and generates PES buffers.

5 The MediaSwitch class 909 fills the buffer up and pushes it back to the TmkClipCache 912 object.

10 The TmkClipCache 912 maintains a cache file 918 on a storage medium. It also maintains two pointers into this cache: a push pointer 919 that shows where the next buffer coming from the source 901 is inserted; and a current pointer 920 which points to the current buffer used.

15 The buffer that is pointed to by the current pointer is handed to the Vela decoder class 916. The Vela decoder class 916 talks to the decoder 921 in the hardware. The decoder 921 produces a decoded TV signal that is subsequently encoded into an analog TV signal in NTSC, PAL or other analog format. When the Vela decoder class 916 is finished with the buffer it calls releaseEmptyBuf.

20 The structure of the classes makes the system easy to test and debug. Each level can be tested separately to make sure it performs in the appropriate manner, and the classes may be gradually aggregated to achieve the desired functionality while retaining the ability to effectively test each object.

25 The control object 917 accepts commands from the user and sends events into the pipeline to control what the pipeline is doing. For example, if the user has a remote control and is watching TV, the user presses pause and the control object 917 sends an event to the sink 903, that tells it pause. The sink 903 stops asking for new buffers. The current pointer 920 stays where it is at. The

sink 903 starts taking buffers out again when it receives another event that tells it to play. The system is in perfect synchronization; it starts from the frame that it stopped at.

5 The remote control may also have a fast forward key. When the fast forward key is pressed, the control object 917 sends an event to the transform 902, that tells it to move forward two seconds. The transform 902 finds that the two second time span requires it to move forward three buffers. It then issues a reset event to the downstream pipeline, so that any queued data or state that may be  
10 present in the hardware decoders is flushed. This is a critical step, since the structure of MPEG streams requires maintenance of state across multiple frames of data, and that state will be rendered invalid by repositioning the pointer. It then moves the current pointer 920 forward three buffers. The next time the sink 903 calls nextFullBuf it gets the new current buffer. The same  
15 method works for fast reverse in that the transform 902 moves the current pointer 920 backwards.

A system clock reference resides in the decoder. The system clock reference is sped up for fast play or slowed down for slow play. The sink simply asks for full  
20 buffers faster or slower, depending on the clock speed.

With respect to Fig. 10, two other objects derived from the TmkXfrm class are placed in the pipeline for disk access. One is called TmkClipReader 1003 and the other is called TmkClipWriter 1001. Buffers come into the TmkClipWriter  
25 1001 and are pushed to a file on a storage medium 1004. TmkClipReader 1003 asks for buffers which are taken off of a file on a storage medium 1005. A TmkClipReader 1003 provides only the allocEmptyBuf and pushFullBuf methods, while a TmkClipWriter 1001 provides only the nextFullBuf and releaseEmptyBuf methods. A TmkClipReader 1003 therefore performs the

same function as the input, or “push” side of a TmkClipCache 1002, while a TmkClipWriter 1001 therefore performs the same function as the output, or “pull” side of a TmkClipCache 1002.

5 Referring to Fig. 11, a preferred embodiment that accomplishes multiple functions is shown. A source 1101 has a TV signal input. The source sends data to a PushSwitch 1102 which is a transform derived from TmkXfrm. The PushSwitch 1102 has multiple outputs that can be switched by the control object 1114. This means that one part of the pipeline can be stopped and  
10 another can be started at the users whim. The user can switch to different storage devices. The PushSwitch 1102 could output to a TmkClipWriter 1106, which goes onto a storage device 1107 or write to the cache transform 1103.

15 An important feature of this apparatus is the ease with which it can selectively capture portions of an incoming signal under the control of program logic. Based on information such as the current time, or perhaps a specific time span, or perhaps via a remote control button press by the viewer, a TmkClipWriter 1106 may be switched on to record a portion of the signal, and switched off at some later time. This switching is typically caused by sending a “switch” event  
20 to the PushSwitch 1102 object.

25 An additional method for triggering selective capture is through information modulated into the VBI or placed into an MPEG private data channel. Data decoded from the VBI or private data channel is passed to the program logic. The program logic examines this data to determine if the data indicates that capture of the TV signal into which it was modulated should begin. Similarly, this information may also indicate when recording should end, or another data item may be modulated into the signal indicating when the capture should end. The starting and ending indicators may be explicitly modulated into the signal or

other information that is placed into the signal in a standard fashion may be used to encode this information.

With respect to Fig. 12, an example is shown which demonstrates how the program logic scans the words contained within the closed caption (CC) fields to determine starting and ending times, using particular words or phrases to trigger the capture. A stream of NTSC or PAL fields 1201 is presented. CC bytes are extracted from each odd field 1202, and entered in a circular buffer 1203 for processing by the Word Parser 1204. The Word Parser 1204 collects characters until it encounters a word boundary, usually a space, period or other delineating character. Recall from above, that the MPEG audio and video segments are collected into a series of fixed-size PES buffers. A special segment is added to each PES buffer to hold the words extracted from the CC field 1205. Thus, the CC information is preserved in time synchronization with the audio and video, and can be correctly presented to the viewer when the stream is displayed. This also allows the stored stream to be processed for CC information at the leisure of the program logic, which spreads out load, reducing cost and improving efficiency. In such a case, the words stored in the special segment are simply passed to the state table logic 1206.

During stream capture, each word is looked up in a table 1206 which indicates the action to take on recognizing that word. This action may simply change the state of the recognizer state machine 1207, or may cause the state machine 1207 to issue an action request, such as "start capture", "stop capture", "phrase seen", or other similar requests. Indeed, a recognized word or phrase may cause the pipeline to be switched; for example, to overlay a different audio track if undesirable language is used in the program.

Note that the parsing state table 1206 and recognizer state machine 1207 may be modified or changed at any time. For example, a different table and state machine may be provided for each input channel. Alternatively, these elements may be switched depending on the time of day, or because of other events.

5

Referring to Fig. 11, a PullSwitch is added 1104 which outputs to the sink 1105. The sink 1105 calls nextFullBuf and releaseEmptyBuf to get or return buffers from the PullSwitch 1104. The PullSwitch 1104 can have any number of inputs. One input could be an ActionClip 1113. The remote control can switch between input sources. The control object 1114 sends an event to the PullSwitch 1104, telling it to switch. It will switch from the current input source to whatever input source the control object selects.

10

An ActionClip class provides for sequencing a number of different stored signals in a predictable and controllable manner, possibly with the added control of viewer selection via a remote control. Thus, it appears as a derivative of a TmkXfrm object that accepts a "switch" event for switching to the next stored signal.

15

This allows the program logic or user to create custom sequences of video output. Any number of video segments can be lined up and combined as if the program logic or user were using a broadcast studio video mixer. TmkClipReaders 1108, 1109, 1110 are allocated and each is hooked into the PullSwitch 1104. The PullSwitch 1104 switches between the TmkClipReaders 1108, 1109, 1110 to combine video and audio clips. Flow control is automatic because of the way the pipeline is constructed. The Push and Pull Switches are the same as video switches in a broadcast studio.

20

25

The derived class and resulting objects described here may be combined in an arbitrary way to create a number of different useful configurations for storing, retrieving, switching and viewing of TV streams. For example, if multiple input and output sections are available, one input is viewed while another is stored, and a picture-in-picture window generated by the second output is used to preview previously stored streams. Such configurations represent a unique and novel application of software transformations to achieve the functionality expected of expensive, sophisticated hardware solutions within a single cost-effective device.

With respect to Fig. 13, a high-level system view is shown which implements a VCR backup. The Output Module 1303 sends TV signals to the VCR 1307. This allows the user to record TV programs directly on to video tape. The invention allows the user to queue up programs from disk to be recorded on to video tape and to schedule the time that the programs are sent to the VCR 1307. Title pages (EPG data) can be sent to the VCR 1307 before a program is sent. Longer programs can be scaled to fit onto smaller video tapes by speeding up the play speed or dropping frames.

The VCR 1307 output can also be routed back into the Input Module 1301. In this configuration the VCR acts as a backup system for the Media Switch 1302. Any overflow storage or lower priority programming is sent to the VCR 1307 for later retrieval.

The Input Module 1301 can decode and pass to the remainder of the system information encoded on the Vertical Blanking Interval (VBI). The Output Module 1303 can encode into the output VBI data provided by the remainder of the system. The program logic may arrange to encode identifying information of various kinds into the output signal, which will be recorded onto tape using the

VCR 1307. Playing this tape back into the input allows the program logic to read back this identifying information, such that the TV signal recorded on the tape is properly handled. For example, a particular program may be recorded to tape along with information about when it was recorded, the source network, etc. When this program is played back into the Input Module, this information can be used to control storage of the signal, presentation to the viewer, etc.

One skilled in the art will readily appreciate that such a mechanism may be used to introduce various data items to the program logic which are not properly conceived of as television signals. For instance, software updates or other data may be passed to the system. The program logic receiving this data from the television stream may impose controls on how the data is handled, such as requiring certain authentication sequences and/or decrypting the embedded information according to some previously acquired key. Such a method works for normal broadcast signals as well, leading to an efficient means of providing non-TV control information and data to the program logic.

Additionally, one skilled in the art will readily appreciate that although a VCR is specifically mentioned above, any multimedia recording device (e.g., a Digital Video Disk-Random Access Memory (DVD-RAM) recorder) is easily substituted in its place.

Although the invention is described herein with reference to the preferred embodiment, one skilled in the art will readily appreciate that other applications may be substituted for those set forth herein without departing from the spirit and scope of the present invention. For example, the invention can be used in the detection of gambling casino crime. The input section of the invention is connected to the casino's video surveillance system. Recorded video is cached and simultaneously output to external VCRs. The user can switch to any video



feed and examine (*i.e.*, rewind, play, slow play, fast forward, etc.) a specific segment of the recorded video while the external VCRs are being loaded with the real-time input video. Accordingly, the invention should only be limited by the Claims included below.

**CLAIMS**

1. A process for the simultaneous storage and play back of multimedia data,  
5 comprising the steps of:

accepting television (TV) broadcast signals, wherein said TV signals are  
based on a multitude of standards, including, but not limited to, National  
Television Standards Committee (NTSC) broadcast, PAL broadcast, satellite  
transmission, DSS, DBS, or ATSC;

10 tuning said TV signals to a specific program;

providing at least one Input Section, wherein said input section converts  
said specific program to an Moving Pictures Experts Group (MPEG) formatted  
stream for internal transfer and manipulation;

15 providing a Media Switch, wherein said Media Switch parses said MPEG  
stream, said MPEG stream is separated into its video and audio components;

storing said video and audio components on a storage device;

20 providing at least one Output Section, wherein said Output Section  
extracts said video and audio components from a storage device;

wherein said Output Section assembles said video and audio components  
into an MPEG stream;

wherein said Output Section sends said MPEG stream to a decoder;

wherein said decoder converts said MPEG stream into TV output signals;

wherein said decoder delivers said TV output signals to a TV receiver; and

25 accepting control commands from a user, wherein said control commands  
are sent through the system and affect the flow of said MPEG stream.

2. The process of claim 1, wherein said Input Section directs said MPEG  
stream to the destination indicated by said control commands.

3. The process of claim 1, wherein said Output Section extracts said video and audio components from the storage device indicated by said control commands.

5 4. The process of claim 1, further comprising the step of:  
creating custom video output sequences, wherein said sequences are specified by a user or program control.

10 5. The process of claim 1, wherein the storing and extracting of said video and audio components from said storage device are performed simultaneously.

6. The process of claim 1, wherein said Media Switch calculates and logically associates a time stamp to said video and audio components.

15 7. The process of claim 1, wherein said Media Switch extracts time stamp values from a digital TV stream and logically associates said time stamp values to said video and audio components.

20 8. The process of claim 1, further comprising the steps of:  
placing said video component into a circular video buffer;  
posting an event in a circular event buffer, wherein said event contains an indication that a video component was found and the location of said video component in said circular video buffer; and  
sending notice of said event posting.

25 9. The process of claim 1, further comprising the steps of:  
placing said audio component into a circular audio buffer;

posting an event in a circular event buffer, wherein said event contains an indication that an audio component was found and the location of said audio component in said circular audio buffer; and  
sending notice of said event posting.

5

10. The process of claims 8 or 9, further comprising the steps of:  
receiving said notice;  
retrieving said event posting from said event buffer; and  
indexing into the appropriate buffer indicated by the type and location  
information in said event buffer.

10

11. The process of claim 10, further comprising the steps of:  
generating a buffer containing the logical audio or video segments in  
order, including ancillary information, wherein each of said logical segments  
points to the appropriate circular buffer location where corresponding audio or  
video components have been placed.

15

12. The process of claim 1, further comprising the step of:  
increasing the decoder system clock rate for fast playback or fast reverse  
playback.

20

13. The process of claim 1, further comprising the step of:  
decreasing the decoder system clock rate for slow playback or slow  
reverse playback.

25

14. The process of claim 1, further comprising the step of:  
combining system audio cues and on-screen displays with said TV output  
signals.

15. The process of claim 1, further comprising the steps of:  
decoding the Vertical Blanking Interval (VBI) data or private data channel  
information from said TV signal; and  
examining said data to determine the starting or ending indicators of a  
specific program.

16. The process of claim 1, further comprising the step of:  
scanning the words contained within the closed caption (CC) fields to  
determine program starting and ending times, wherein particular words or  
phrases are used to trigger the recording of a specific program and wherein the  
CC information is preserved in time synchronization with the audio and video,  
and can be correctly presented to the viewer when the stream is displayed.

17. The process of claim 16, further comprising the step of:  
performing a specific action when a specific word is found in said CC  
information.

18. The process of claim 1, wherein said Media Switch has a data bus  
connecting it to a CPU and DRAM.

19. The process of claim 1, wherein said Media Switch shares an address bus  
with a CPU and DRAM.

20. The process of claim 1, wherein said Media Switch operates  
asynchronously and autonomously with a CPU.

21. The process of claim 1, wherein a storage device is connected to said  
Media Switch.

22. The process of claim 1, wherein said Media Switch allows the CPU to queue up Direct Memory Access (DMA) transfers.

23. The process of claim 1, wherein said Media Switch is implemented in hardware.

24. The process of claim 1, further comprising the step of:

providing a multimedia recording device, including, but not limited to, a Video Cassette Recorder (VCR) or a Digital Video Disk-Random Access Memory (DVD-RAM) device, wherein said recording device is attached to the output side of said decoder, allowing said user to record said TV output signals.

25. The process of claim 24, wherein said user queues up programs from said disk to be stored on said recording device.

26. The process of claim 24, wherein said user sets time schedules for said programs to be sent to said recording device.

27. The process of claim 24, wherein title pages may be sent to said recording device before sending a program to be stored on said recording device.

28. The process of claim 24, wherein a program that is longer in duration than a magnetic tape in said recording device allows, is sped up to fit within the desired time limit.

29. The process of claim 24, wherein a program that is longer in duration than a magnetic tape in said recording device allows, has frames dropped from it to fit within the desired time limit.

30. The process of claim 24, wherein the output of said recording device is routed to said input section, allowing said recording device to act as a storage back up system, said recording device accepts overflow storage, TV programs, software updates, or other data that are later retrieved and sent to said input section.

31. A process for the simultaneous storage and play back of multimedia data, comprising the steps of:

providing a physical data source, wherein said physical data source accepts broadcast data from an input device, parses video and audio data from said broadcast data, and temporarily stores said video and audio data;

providing a source object, wherein said source object extracts video and audio data from said physical data source;

providing a transform object, wherein said transform object stores and retrieves data streams onto a storage device;

wherein said source object obtains a buffer from said transform object, said source object converts video data into data streams and fills said buffer with said streams;

wherein said source object is automatically flow controlled by said transform object;

providing a sink object, wherein said sink object obtains data stream buffers from said transform object and outputs said streams to a video and audio decoder;

wherein said decoder converts said streams into display signals and sends said signals to a display;

wherein said sink object is automatically flow controlled by said transform object;

providing a control object, wherein said control object receives commands from a user, said commands control the flow of the broadcast data through the system; and

wherein said control object sends flow command events to said source, transform, and sink objects.

32. An apparatus for the simultaneous storage and play back of multimedia data, comprising:

a module for accepting television (TV) broadcast signals, wherein said TV signals are based on a multitude of standards, including, but not limited to, National Television Standards Committee (NTSC) broadcast, PAL broadcast, satellite transmission, DSS, DBS, or ATSC;

a module for tuning said TV signals to a specific program;

at least one Input Section, wherein said input section converts said specific program to an Moving Pictures Experts Group (MPEG) formatted stream for internal transfer and manipulation;

a Media Switch, wherein said Media Switch parses said MPEG stream, said MPEG stream is separated into its video and audio components;

a module for storing said video and audio components on a storage device;

at least one Output Section, wherein said Output Section extracts said video and audio components from a storage device;

wherein said Output Section assembles said video and audio components into an MPEG stream;

wherein said Output Section sends said MPEG stream to a decoder;

wherein said decoder converts said MPEG stream into TV output signals;

wherein said decoder delivers said TV output signals to a TV receiver; and

accepting control commands from a user, wherein said control commands are sent through the system and affect the flow of said MPEG stream.



33. The apparatus of claim 32, wherein said Input Section directs said MPEG stream to the destination indicated by said control commands.

5 34. The apparatus of claim 32, wherein said Output Section extracts said video and audio components from the storage device indicated by said control commands.

10 35. The apparatus of claim 32, further comprising:  
a module for creating custom video output sequences, wherein said sequences are specified by a user or program control.

15 36. The apparatus of claim 32, wherein the storing and extracting of said video and audio components from said storage device are performed simultaneously.

37. The apparatus of claim 32, wherein said Media Switch calculates and logically associates a time stamp to said video and audio components.

20 38. The apparatus of claim 32, wherein said Media Switch extracts time stamp values from a digital TV stream and logically associates said time stamp values to said video and audio components.

25 39. The apparatus of claim 32, further comprising:  
a module for placing said video component into a circular video buffer;  
a module for posting an event in a circular event buffer, wherein said event contains an indication that a video component was found and the location of said video component in said circular video buffer; and  
a module for sending notice of said event posting.

40. The apparatus of claim 32, further comprising:  
a module for placing said audio component into a circular audio buffer;  
a module for posting an event in a circular event buffer, wherein said event  
contains an indication that an audio component was found and the location of  
said audio component in said circular audio buffer; and  
a module for sending notice of said event posting.

41. The apparatus of claims 39 or 40, further comprising:  
a module for receiving said notice;  
a module for retrieving said event posting from said event buffer; and  
a module for indexing into the appropriate buffer indicated by the type and  
location information in said event buffer.

42. The apparatus of claim 41, further comprising:  
a module for generating a buffer containing the logical audio or video  
segments in order, including ancillary information, wherein each of said logical  
segments points to the appropriate circular buffer location where corresponding  
audio or video components have been placed.

43. The apparatus of claim 32, further comprising:  
a module for increasing the decoder system clock rate for fast playback or  
fast reverse playback.

44. The apparatus of claim 32, further comprising:  
a module for decreasing the decoder system clock rate for slow playback  
or slow reverse playback.

45. The apparatus of claim 32, further comprising:  
a module for combining system audio cues and on-screen displays with  
said TV output signals.

5 46. The apparatus of claim 32, further comprising:  
a module for decoding the Vertical Blanking Interval (VBI) data or private  
data channel information from said TV signal; and  
a module for examining said data to determine the starting or ending  
indicators of a specific program.

10

47. The apparatus of claim 32, further comprising:  
a module for scanning the words contained within the closed caption (CC)  
fields to determine program starting and ending times, wherein particular words  
or phrases are used to trigger the recording of a specific program and wherein  
15 the CC information is preserved in time synchronization with the audio and  
video, and can be correctly presented to the viewer when the stream is  
displayed.

15

48. The apparatus of claim 47, further comprising:  
a module for performing a specific action when a specific word is found in  
said CC information.

20

49. The apparatus of claim 32, wherein said Media Switch has a data bus  
connecting it to a CPU and DRAM.

25

50. The apparatus of claim 32, wherein said Media Switch shares an address  
bus with a CPU and DRAM.

51. The apparatus of claim 32, wherein said Media Switch operates asynchronously and autonomously with a CPU.

52. The apparatus of claim 32, wherein a storage device is connected to said Media Switch.

53. The apparatus of claim 32, wherein said Media Switch allows the CPU to queue up Direct Memory Access (DMA) transfers.

54. The apparatus of claim 32, further comprising:  
a multimedia recording device, including, but not limited to, a Video Cassette Recorder (VCR) or a Digital Video Disk-Random Access Memory (DVD-RAM) device, wherein said recording device is attached to the output side of said decoder, allowing said user to record said TV output signals.

55. The apparatus of claim 54, wherein said user queues up programs from said disk to be stored on said recording device.

56. The apparatus of claim 54, wherein said user sets time schedules for said programs to be sent to said recording device.

57. The apparatus of claim 54, wherein title pages may be sent to said recording device before sending a program to be stored on said recording device.

58. The apparatus of claim 54, wherein a program that is longer in duration than a magnetic tape in said recording device allows, is sped up to fit within the desired time limit.

59. The apparatus of claim 54, wherein a program that is longer in duration than a magnetic tape in said recording device allows, has frames dropped from it to fit within the desired time limit.

5 60. The apparatus of claim 54, wherein the output of said recording device is routed to said input section, allowing said recording device to act as a storage back up system, said recording device accepts overflow storage, TV programs, software updates, or other data that are later retrieved and sent to said input section.

10 61. An apparatus for the simultaneous storage and play back of multimedia data, comprising:

15 a physical data source, wherein said physical data source accepts broadcast data from an input device, parses video and audio data from said broadcast data, and temporarily stores said video and audio data;

a source object, wherein said source object extracts video and audio data from said physical data source;

a transform object, wherein said transform object stores and retrieves data streams onto a storage device;

20 wherein said source object obtains a buffer from said transform object, said source object converts video data into data streams and fills said buffer with said streams;

wherein said source object is automatically flow controlled by said transform object;

25 a sink object, wherein said sink object obtains data stream buffers from said transform object and outputs said streams to a video and audio decoder;

wherein said decoder converts said streams into display signals and sends said signals to a display;

wherein said sink object is automatically flow controlled by said transform object;

a control object, wherein said control object receives commands from a user, said commands control the flow of the broadcast data through the system;

5 and

wherein said control object sends flow command events to said source, transform, and sink objects.

## MULTIMEDIA TIME WARPING SYSTEM

### ABSTRACT

5 A multimedia time warping system. The invention allows the user to store  
selected television broadcast programs while the user is simultaneously  
watching or reviewing another program. A preferred embodiment of the  
invention accepts television (TV) input streams in a multitude of forms, for  
example, National Television Standards Committee (NTSC) or PAL broadcast,  
and digital forms such as Digital Satellite System (DSS), Digital Broadcast  
10 Services (DBS), or Advanced Television Standards Committee (ATSC). The  
TV streams are converted to an Moving Pictures Experts Group (MPEG)  
formatted stream for internal transfer and manipulation and are parsed and  
separated it into video and audio components. The components are stored in  
temporary buffers. Events are recorded that indicate the type of component that  
15 has been found, where it is located, and when it occurred. The program logic is  
notified that an event has occurred and the data is extracted from the buffers.  
The parser and event buffer decouple the CPU from having to parse the MPEG  
stream and from the real time nature of the data streams which allows for slower  
CPU and bus speeds and translate to lower system costs. The video and audio  
20 components are stored on a storage device and when the program is requested  
for display, the video and audio components are extracted from the storage  
device and reassembled into an MPEG stream which is sent to a decoder. The  
decoder converts the MPEG stream into TV output signals and delivers the TV  
output signals to a TV receiver. User control commands are accepted and sent  
25 through the system. These commands affect the flow of said MPEG stream and  
allow the user to view stored programs with at least the following functions:  
reverse, fast forward, play, pause, index, fast/slow reverse play, and fast/slow  
play.

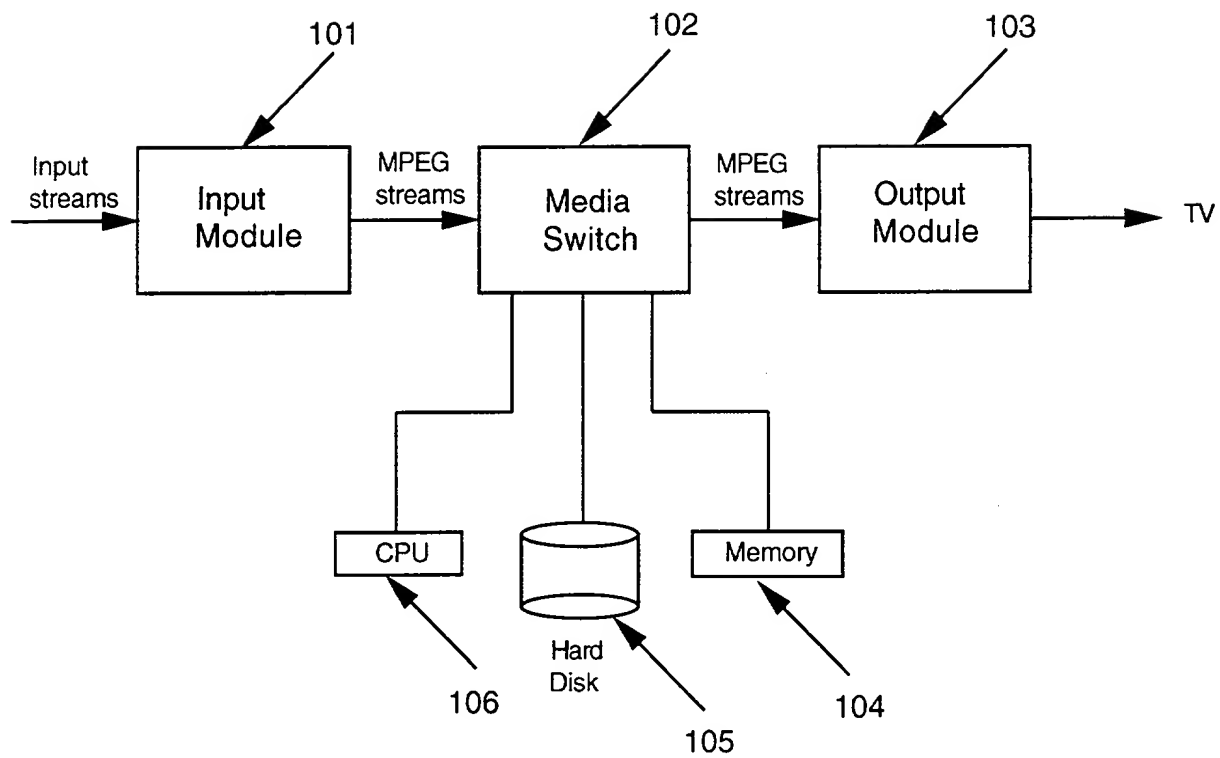


Fig. 1



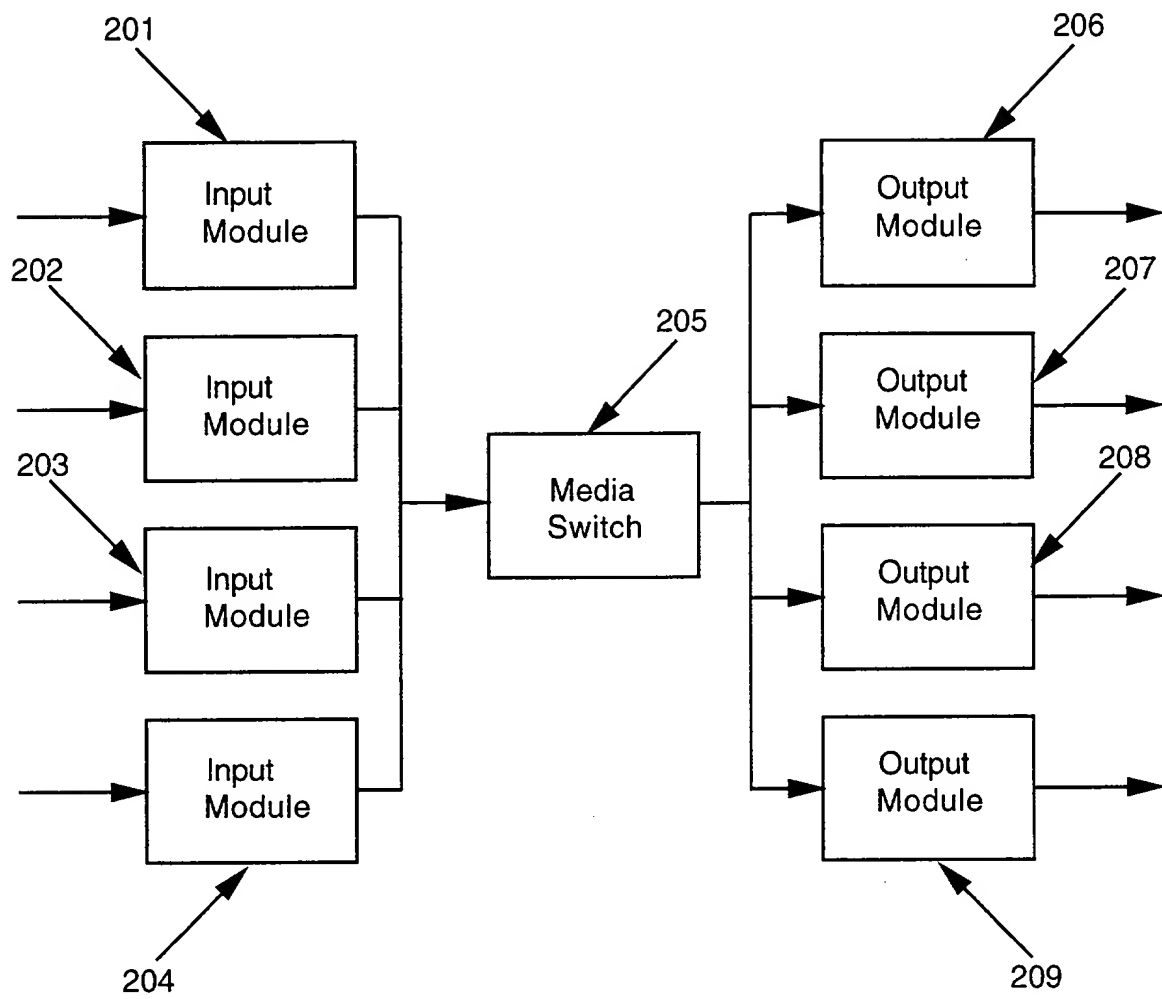


Fig. 2

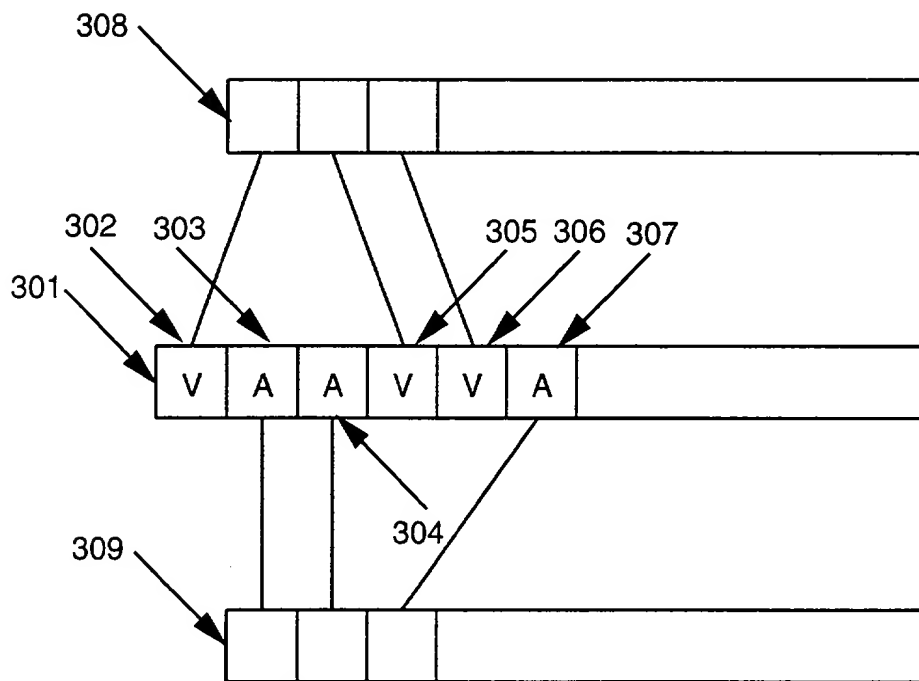


Fig. 3

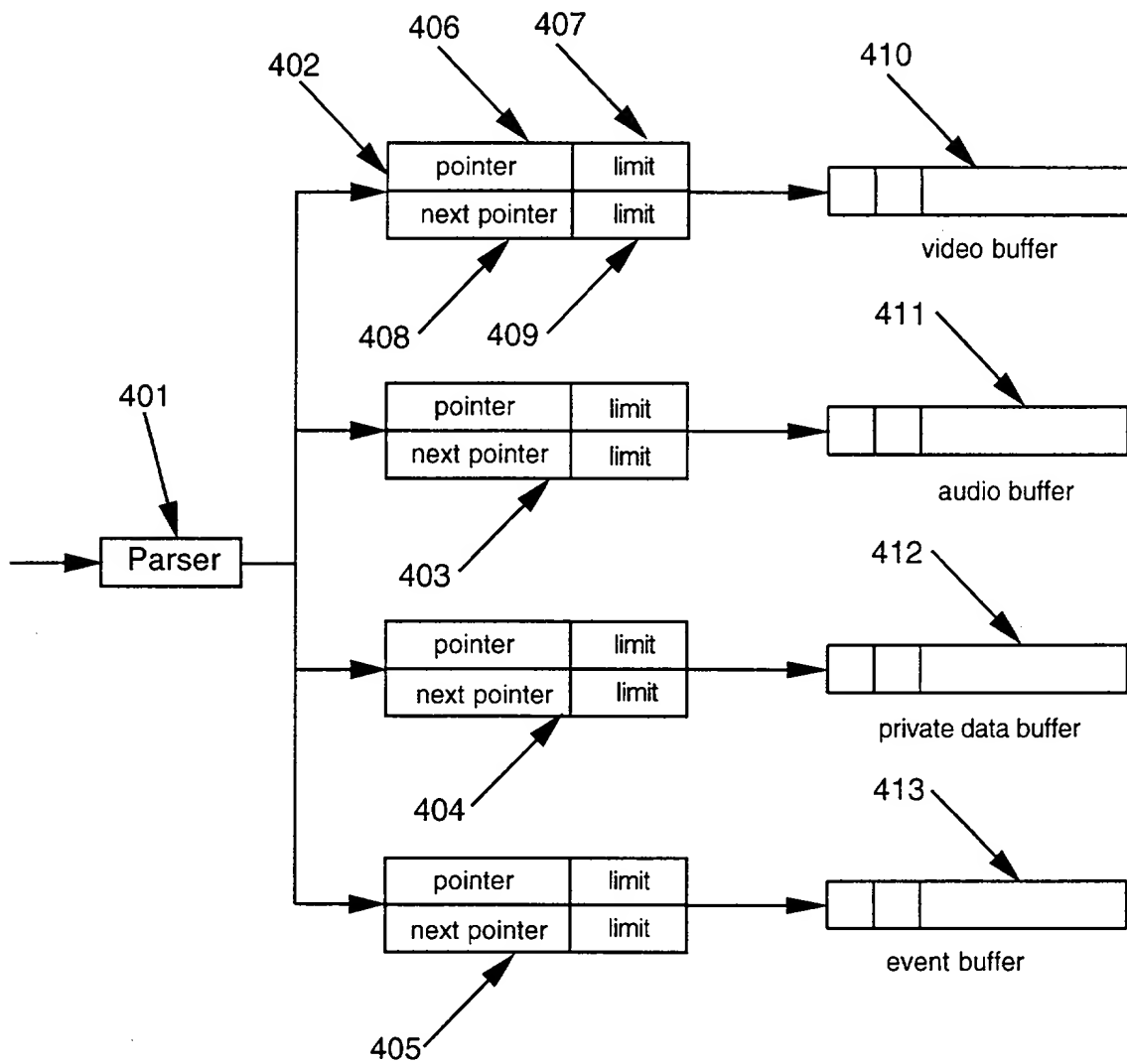


Fig. 4

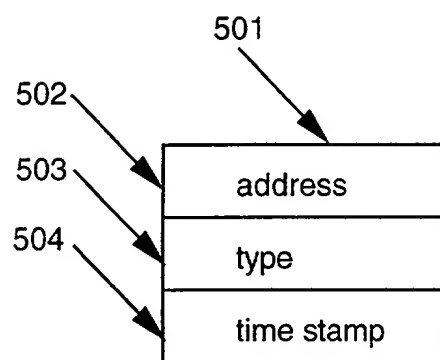
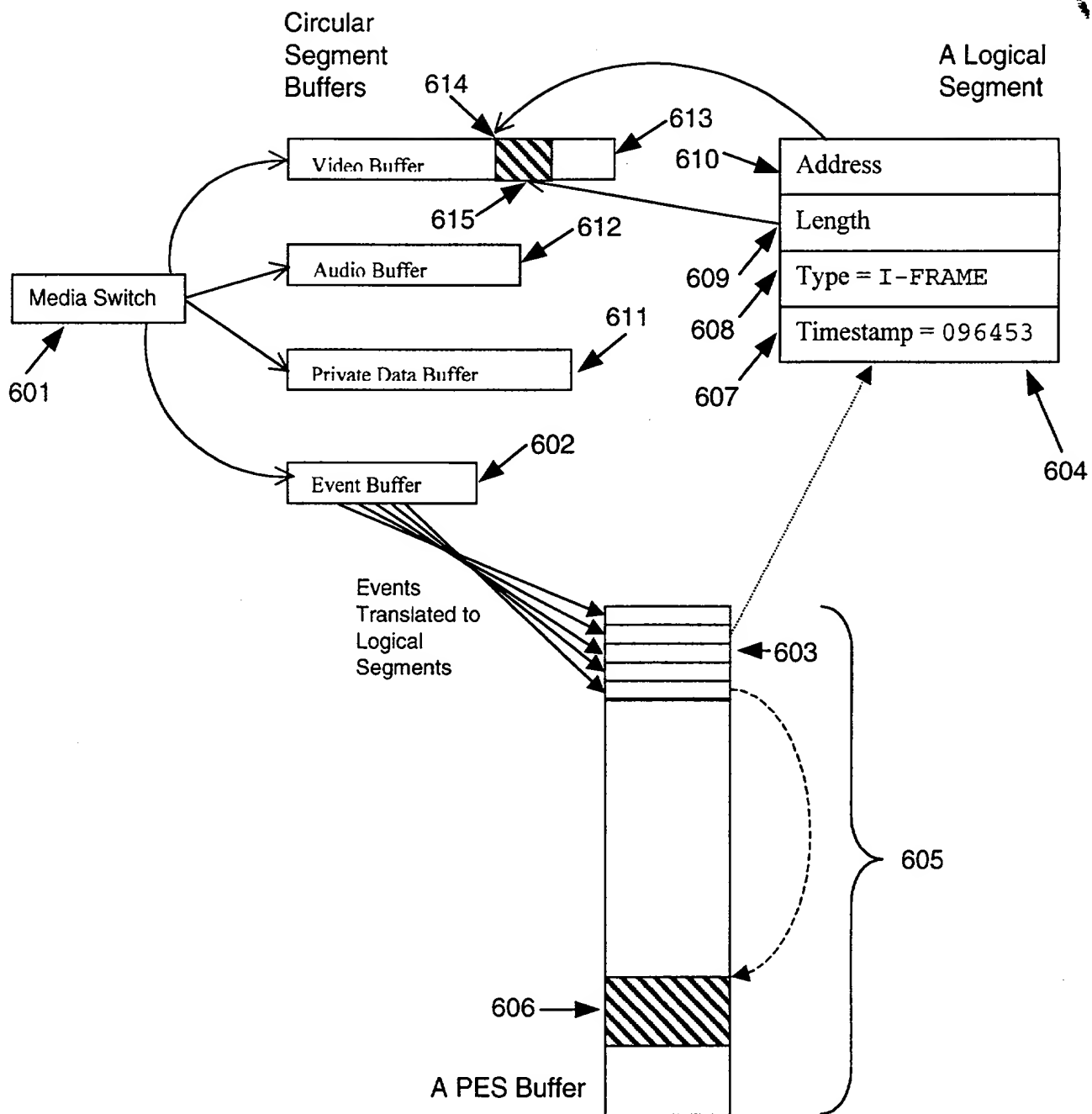


Fig. 5



**Fig. 6**

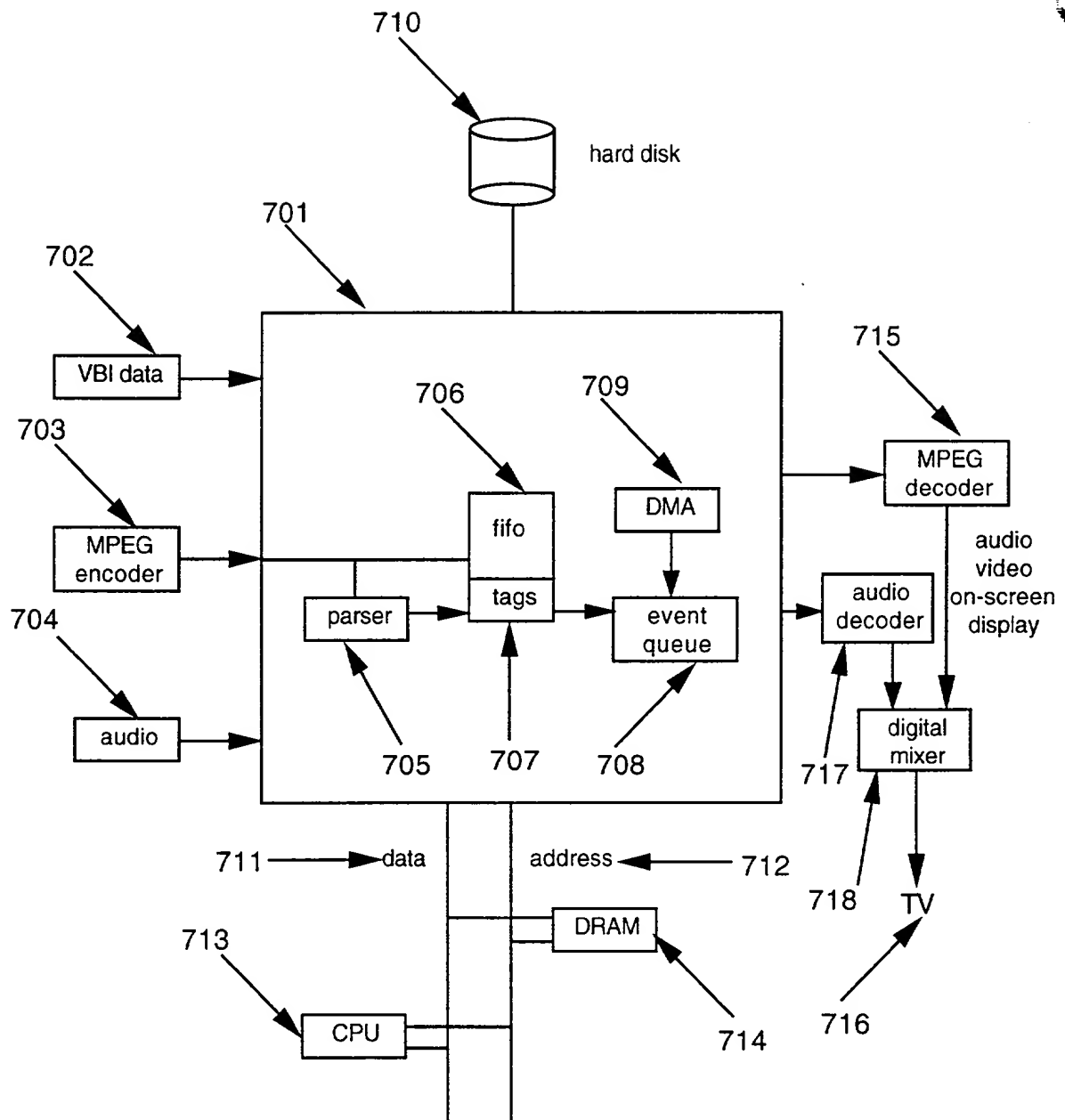


Fig. 7

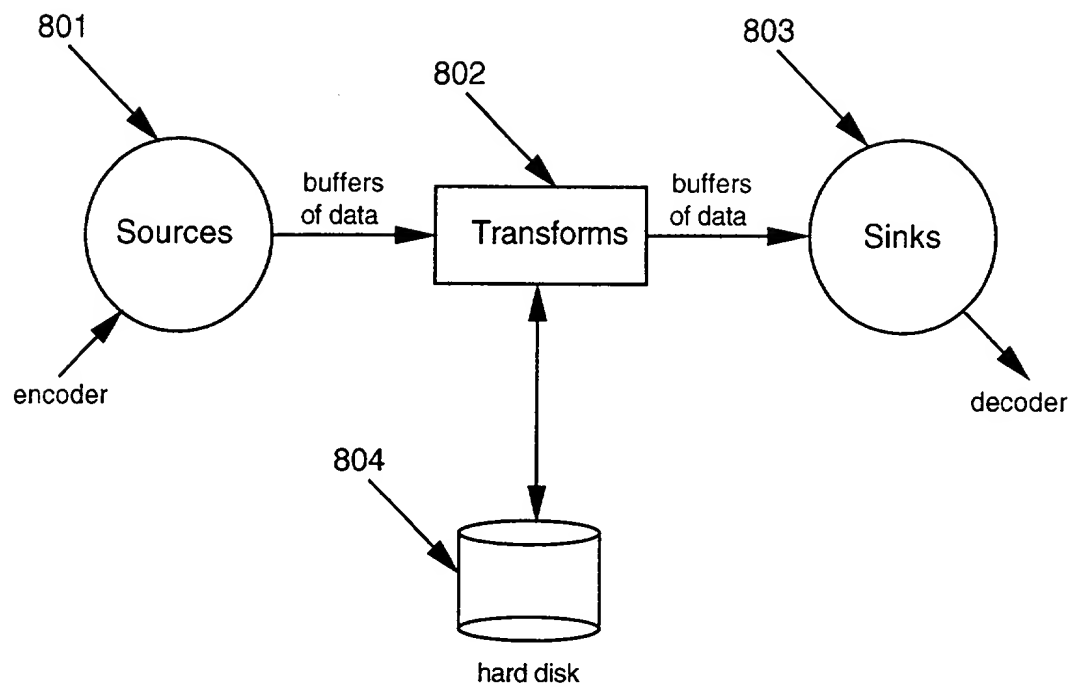


Fig. 8

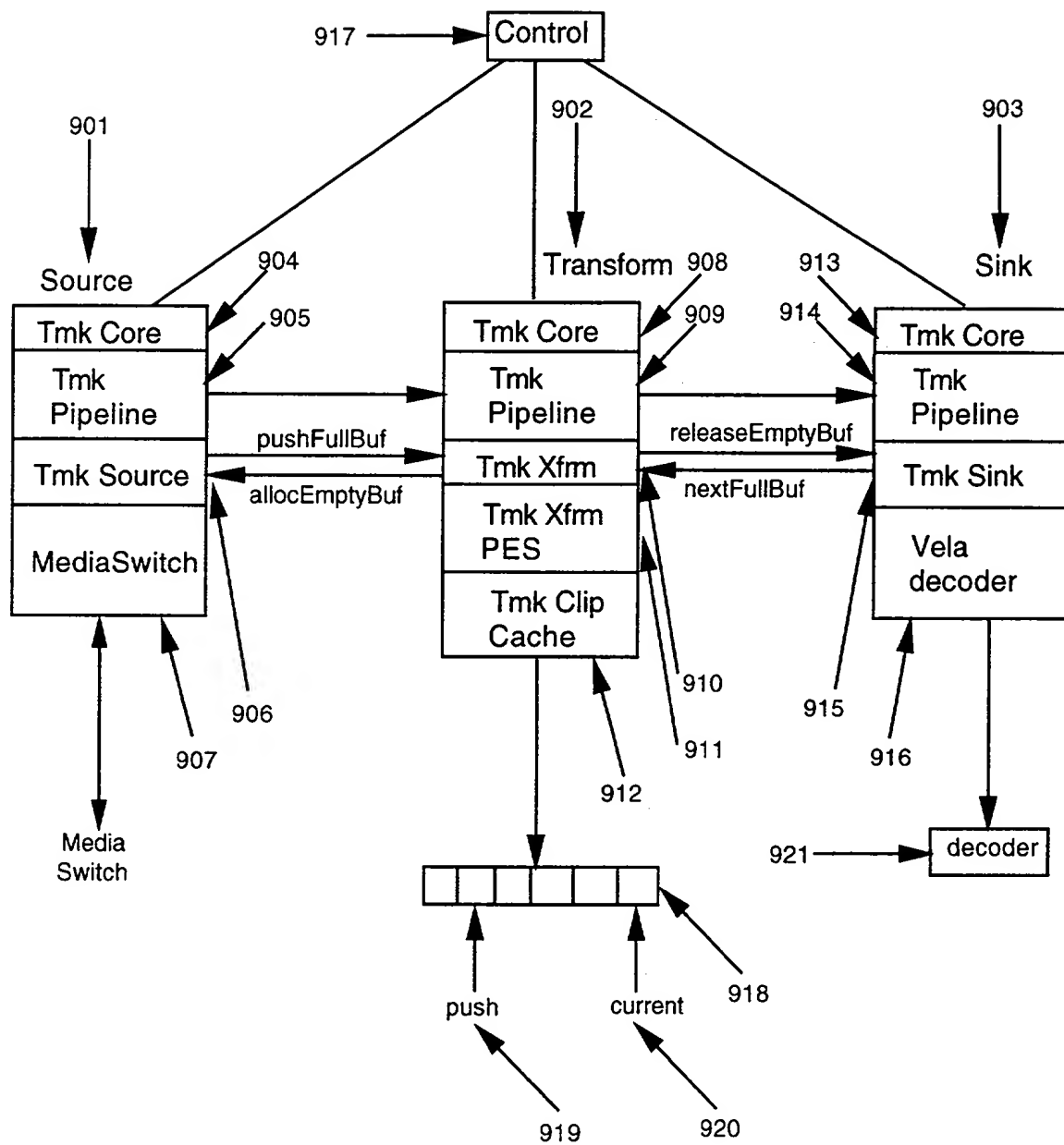


Fig. 9



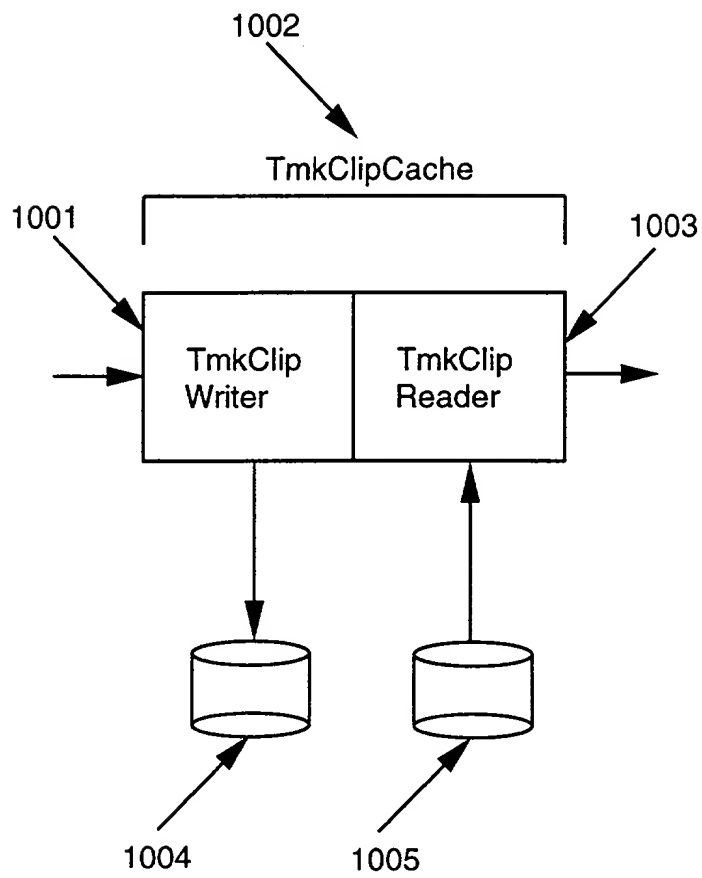


Fig. 10

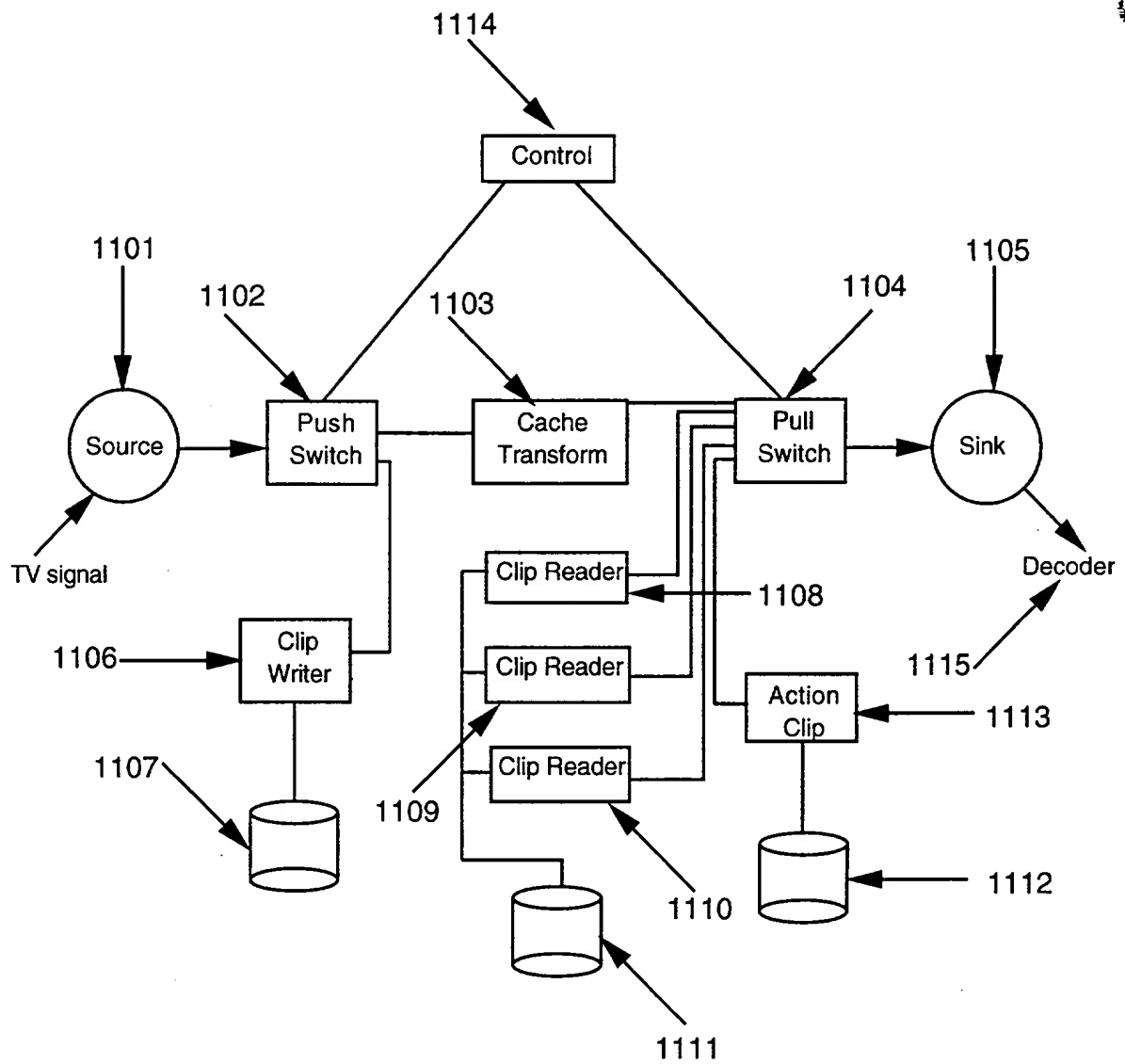


Fig. 11

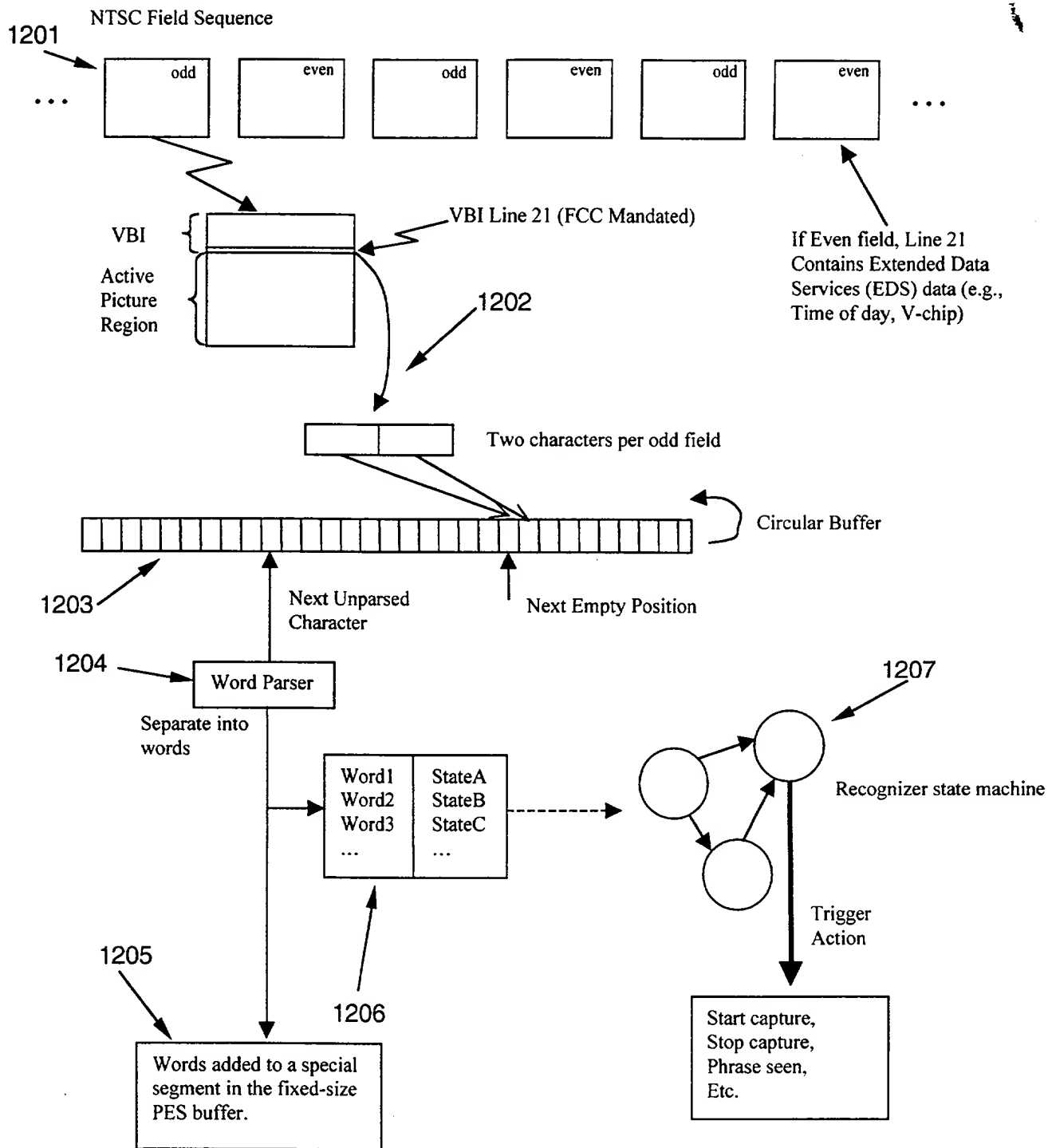
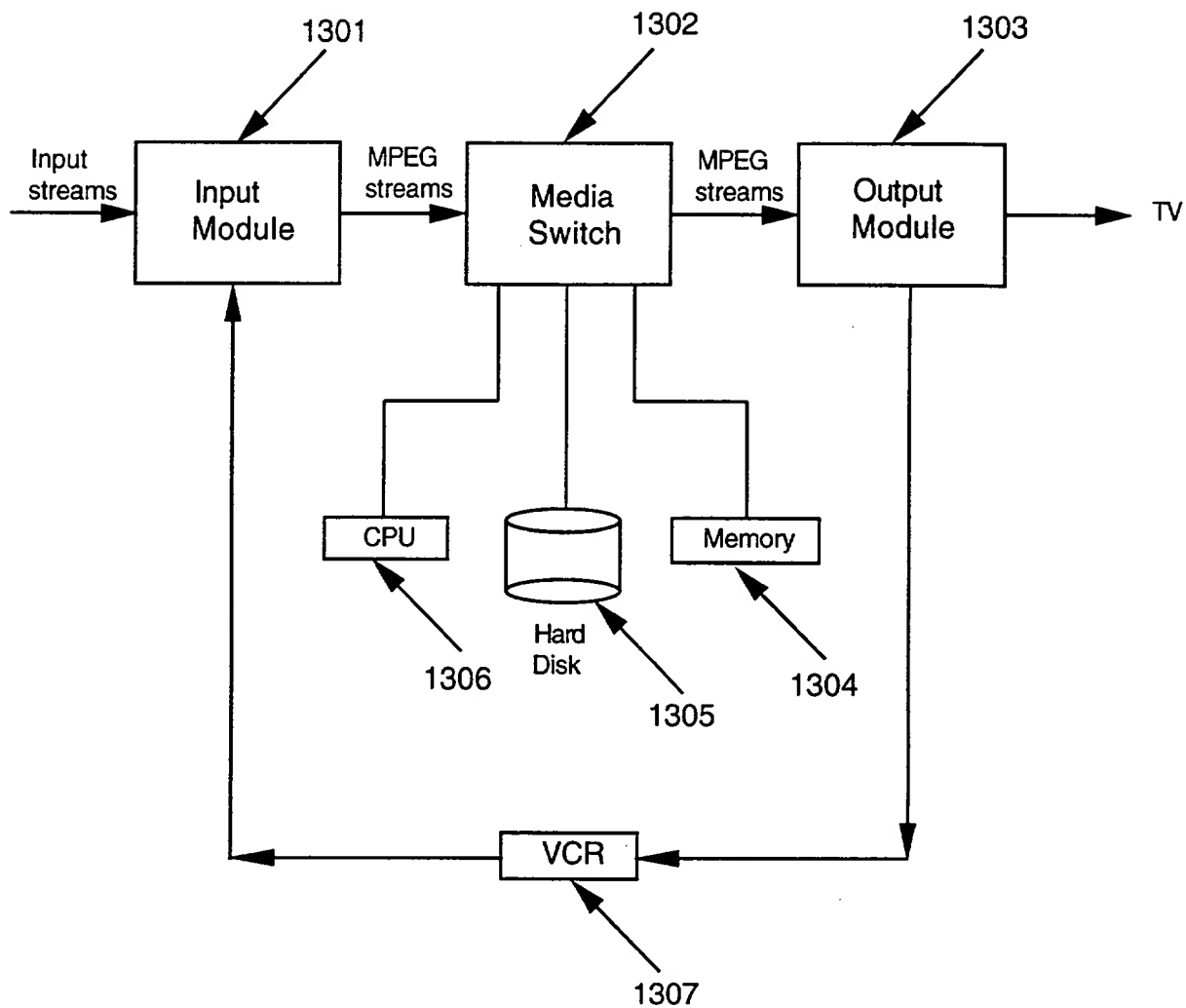


Fig. 12



**Fig. 13**

**DECLARATION FOR PATENT APPLICATION**

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name;

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**MULTIMEDIA TIME WARPING SYSTEM**

the specification of which (check one)  X  is attached hereto, or \_\_\_\_ was filed on \_\_\_\_\_ as Application Serial No. \_\_\_\_\_ and was amended on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

=====

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed  
Yes      No

\_\_\_\_\_  
Number    Country    Day/Month/Year Filed

\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
Number    Country    Day/Month/Year Filed

\_\_\_\_\_  
\_\_\_\_\_

=====

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

MICHAEL A. GLENN, Reg. No. 30,176  
DONALD M. HENDRICKS, Reg. No. 40,355  
KIRK D. WONG, Reg. No. P-43,284

SEND CORRESPONDENCE TO:

MICHAEL A. GLENN, P.O. Box 7831, Menlo Park, CA 94026

I hereby claim the benefit under Title 35, United States code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application Ser. No.

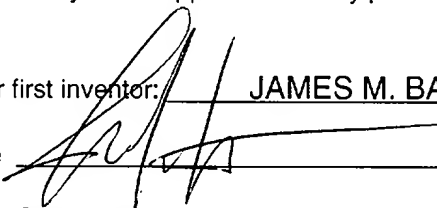
Filing Date

Status: Patented, Pending, Abandoned

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor: JAMES M. BARTON

Inventor's signature



7/27/98  
Date

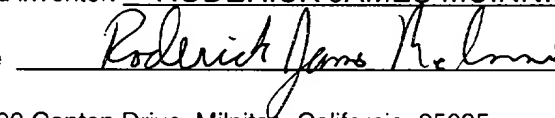
Residence 101 Sund Avenue, Los Gatos, California 95032

Post Office Address Same

Citizenship United States of America

Full name of second inventor: RODERICK JAMES MCINNIS

Inventor's signature



7/21/98  
Date

Residence 1299 Canton Drive, Milpitas, California 95035

Post Office Address Same

Citizenship United States of America

Full name of third inventor: ALAN S. MOSKOWITZ

Inventor's signature



24 July 1998  
Date

Residence 300 Third Street, San Francisco, California 94107

Post Office Address Same

Citizenship United States of America

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Full name of fourth inventor: ANDREW MARTIN GOODMAN


Inventor's signature *Audrey Gooden* 7/27/98  
Date

Residence 2171 Avy Avenue, Menlo Park, California 94025

Post Office Address Same

Citizenship United States of America

Full name of fifth inventor: CHING TONG CHOW

Inventor's signature  7/21/98  
Date

Residence 920 Seville Place, Fremont, California 94539

Post Office Address Same

Citizenship Hong Kong

Full name of sixth inventor: JEAN SWEY KAO

Inventor's signature Jerome Sway 7/24/98  
Date

Residence 21876 Meadow View Lane, Cupertino, California 95014

Post Office Address Same

Citizenship United States of America

Applicants or Patentees: James M. Barton, Roderick J. McInnis, Alan Moskowitz, Andrew Goodman, Ching Tong Chow, and Jean Kao

Serial No.: Unassigned Filing Date: Herewith  
Patent No.: Unassigned Issued: Unassigned

For: **MULTIMEDIA TIME WARPING SYSTEM**

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS  
37 CFR 1.9(f) and 1.27(b) - SMALL BUSINESS CONCERN

I hereby declare that I am:

( ) the owner of the small business concern identified below:

(X) an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN TiVo, Inc.

ADDRESS OF CONCERN 894 Ross Drive, Suite 100, Sunnyvale, California 94089

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3 - 18 and reproduced in 37 CFR 1.9(c) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time, or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention entitled: **MULTIMEDIA TIME WARPING** by inventor(s) **James M. Barton, Roderick J. McInnis, Alan Moskowitz, Andrew Goodman, Ching Tong Chow, and Jean Kao** described in:

(x) the application filed herewith

( ) application serial no. \_\_\_\_\_, filed \_\_\_\_\_

( ) patent no. \_\_\_\_\_, issued \_\_\_\_\_

If the rights held by the above-identified small business concern are not exclusive, each individual, concern, or organization having rights to the invention is listed below\* and no rights to the invention are held by any person, other than an inventor, who could not qualify as a small business concern under 37 CFR 1.9(d), or by any concern that could not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

( ) no such person, concern, or organization

( ) persons, concerns, or organizations listed below\*

\* NOTE: Separate verified statements are required from each named person, concern, or organization having rights to the invention averring to their status as small entities (37 CFR 1.27).



Name: JAMES M. BARTON

Date

Signature of Inventor

Date \_\_\_\_\_

Signature of Inventor

Date \_\_\_\_\_

Signature of Inventor

Date \_\_\_\_\_

Signature of Inventor

Date \_\_\_\_\_

Signature of Inventor

Date \_\_\_\_\_

Applicants or Patentees: James M. Barton, Roderick McInnis, Alan Moskowitz, Andrew Goodman, Ching Tong Chow, and Jean Kao

Serial No.: \_\_\_\_\_ Filing Date: Herewith

Patent No.: \_\_\_\_\_ Issued: \_\_\_\_\_

For: **MULTIMEDIA TIME WARPING SYSTEM**

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS**  
**37 CFR 1.9(f) and 1.27(b) - INDEPENDENT INVENTOR**

As a below-named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled:

**MULTIMEDIA TIME WARPING SYSTEM**

described in:

☒ the application filed herewith

☐ application serial no. \_\_\_\_\_, filed \_\_\_\_\_

☐ patent no. \_\_\_\_\_, issued \_\_\_\_\_

I have not assigned, granted, conveyed, or licensed and am under no obligation under contract or law to assign, grant, convey, or license any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

☒ no such person, concern, or organization

☐ persons, concerns, or organizations listed below\*

\* NOTE: Separate verified statements are required from each named person, concern, or organization having rights to the invention averring to their status as small entities (37 CFR 1.27).

FULL NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

FULL NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 CFR 1.28(b)).

FULL NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

( ) INDIVIDUAL ( ) SMALL BUSINESS CONCERN ( ) NONPROFIT ORGANIZATION

FULL NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

( ) INDIVIDUAL ( ) SMALL BUSINESS CONCERN ( ) NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING James M. Barton

TITLE OF PERSON OTHER THAN OWNER Chief Technical Officer & Vice President Engineering

ADDRESS OF PERSON SIGNING 101 Sund Avenue

Los Gatos, California 95032

SIGNATURE \_\_\_\_\_

DATE 7/27/18

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